Insurance Design for Developing Countries

Daniel Clarke

Department of Statistics, University of Oxford
Centre for the Study of African Economies, University of Oxford

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In the Background section, it is explained that being poor is risky due to exposure to agricultural, income, health, and mortality shocks. Approximately one third of dollar-a-day poverty is transient. Exposure to risk leads to cautious behavior, including avoiding costly inputs, choosing safe activities, and keeping unproductive liquid assets and small stocks. However, despite these arrangements, individuals are still exposed to covariate shocks such as agricultural production shocks and large health shocks. 

Daniel Clarke's work focuses on insurance design for developing countries, aiming to address the risks faced by the poor.
An introduction to hedging in agriculture

Motivation:

- Agriculture is an uncertain business, particularly for the poor (Dercon 2004, Collins et al. 2009)

- Traditional indemnity-based approaches to crop insurance were unsustainable (Hazell 1992, Skees et al. 1999).

- Hedging products can be fairly cheap whilst still offering protection against key perils (Hess et al. 2005).
An introduction to hedging in agriculture

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Examples of hedging products currently being sold to poor farmers:

- Weather indexed insurance (rainfall, temperature, humidity, wind speed, etc.)
- Flood indexed insurance
- Area yield indexed insurance
- Remote sensing indexed insurance (NDVI, WRSI, etc.)
- Livestock index insurance
Questions:

1. When ‘should’ consumers purchase a hedge against a potentially material loss?

2. Do Ethiopian farmers make ‘good’ decisions about hedging products?

3. What sort of insurance arrangements might be most appropriate for the poor?

Toolkit:

- Economic theory
  - Decision under uncertainty
  - Mechanism design
- Randomized experiments
Overview

1. Introduction
2. Chapter I
3. Chapter II
4. Chapter III
5. Conclusion
Two puzzles of weather derivatives for the poor

1. Demand for weather derivatives is lower than expected
2. Demand is particularly low for the most risk averse
Two puzzles of weather derivatives for the poor

1. Demand for weather derivatives is lower than expected
2. Demand is particularly low for the most risk averse

Key empirical papers include:

- Giné et al. (2008) India (AP): 5% uptake
- Giné and Yang (2008) Malawi: 13% fewer people take up loan with weather derivative than loan without
- Cole et al. (2009) India (AP and Gujarat): 5-10% buy product, hedging only 2-5% of household agricultural income
Two puzzles of weather derivatives for the poor

1. Demand for weather derivatives is lower than expected
2. Demand is particularly low for the most risk averse

Explanations include:

‘Insurance purchase is sensitive to price [...] credit constraints [...] trust’ (Cole et al. 2009)

‘The most likely explanation [for demand falling with risk aversion] is that it is uncertainty about the product itself (Is it reliable? How fast are pay-outs? How great is basis risk?) that drives down demand.’ (Karlan and Morduch 2009)

‘Poor farmers on the other hand are not sufficiently well insured and would benefit from purchase of insurance, but they are severely cash and credit constrained.’ (Binswanger-Mkhize 2011)
Two puzzles of weather derivatives for the poor

1. Demand for weather derivatives is lower than expected
2. Demand is particularly low for the most risk averse

This paper can (partially) explain the puzzles as objective, rational responses to basis risk and actuarially unfair price:

- Basis risk:= the risk that the net income from the financial contract does not accurately reflect the incurred loss
- Actuarially unfair price:= \( \mathbb{E}[\text{Net transfer to insurer}] > 0 \)

Mathematical framework encompasses all (perceived) risk of contractual nonperformance, including trust, exclusions, insurer default, etc. (Doherty and Schlesinger 1990).
The 2 × 2 state model

- Initial background wealth \( w \), exposed to loss of \( L \)
- Loss and index are imperfectly correlated with joint probability structure:

\[
\begin{array}{c|c|c}
\text{Index} = 0 & \text{Index} = I \\
\hline
\text{Loss} = 0 & 1 - q - r & q + r - p \\
\text{Loss} = L & r & p - r \\
\hline
1 - q & q & p
\end{array}
\]

- Basis risk, \( r = \mathbb{P}[\text{Loss} = L \cap \text{Index} = 0] \)
  - Positive basis risk: \( r > 0 \)
  - Index and loss are affiliated: \( r < p(1 - q) \)
- Can purchase indexed cover of \( \alpha L \) at premium multiple of \( m \):
  - Premium of \( \alpha q m L \) buys claim payment of \( \alpha L \) if \( \text{Index} = I \)
- Consumer is strictly risk averse expected utility maximiser
  - Utility function \( u \) with \( u' > 0 \) and \( u'' < 0 \)
### Result without basis risk

(Indemnity insurance, \( r = 0 \))

<table>
<thead>
<tr>
<th>Shape of rational hedging:</th>
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<tbody>
<tr>
<td>• More risk averse ⇒ buy more coverage</td>
</tr>
<tr>
<td>• Infinitely risk averse ⇒ ( \alpha = 1 )</td>
</tr>
<tr>
<td>• Fair price ((m = 1)) ⇒ ( \alpha = 1 )</td>
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<td>• Positive loading ((m &gt; 1)) ⇒ buy less coverage</td>
</tr>
<tr>
<td>• Insurance is inferior for DARA utility</td>
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<tr>
<td>• Larger potential loss (L) ⇒ buy more coverage for DARA utility</td>
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### Result with basis risk

(Indexed cover, \( r > 0 \))

<table>
<thead>
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<th>Shape of rational hedging:</th>
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### Level of rational hedging:

| ? |

| • Positive loading \((m > 1)\) ⇒ any level of cover \( \alpha \in [0, 1] \) is optimal for some strictly risk averse, DARA utility function \( u \) | ? |
Theorem 1: Infinitely risk averse consumer

Probability mass functions

Uninsured

100% indemnity insurance
Theorem 1: Infinitely risk averse consumer

Probability mass functions

Uninsured

100% indemnity insurance

50% indexed cover
Theorem 1: Infinitely risk averse consumer

For an infinitely risk averse, maximin, consumer:

- Indemnity insurance \((r = 0)\): \(\alpha = 1\)
- Indexed cover \((r > 0)\): \(\alpha = 0\)

\(\Rightarrow\) optimal purchase cannot be everywhere increasing in risk aversion.
Theorem 2: Changes in risk aversion

Optimal purchase of index insurance for maize in a developing country, from decision makers with CRRA utility function.
Theorems 3 and 4: Bounds for rational demand

For the numerical example of maize in a developing country...

... no risk averse expected utility maximiser will optimally purchase any weather indexed insurance if $m > 1.751$. Cf.:

- Giné et al. (2007): Average premium multiple of 3.4
- Cole et al. (2009): Premium multiples of seven products, ranging from 1.7 to 5.3
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Lab experiment in Ethiopia
Benchmark: Binswanger lottery

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<td>65</td>
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Index insurance decision problem

- Subjects start with (physical) endowment of 65 Birr
- But loss of 50 Birr with probability $\frac{1}{2}$
- Compound lottery (wheel spin + bag draw)

Can purchase between 0 and 5 units of index insurance

- One unit of insurance costs 3 Birr
- Claim payment of 5 Birr if the wheel selects the yellow bag
Scatter plot and kernel regression

Figure: Choice in decision problem against livestock owned

(a) Decision problem $T_X$  (b) Decision problem $B$

The figures show the point estimate and 95% confidence intervals for an Epanechnikov kernel with a bandwidth of 0.8 and trimming of 0.05.
171 out of 258 rural Ethiopian participants (66%) chose premiums above 6 Birr...

...but Theorem 4 (Chapter I) $\Rightarrow$ no risk averse DARA EUT maximiser would ever pay premium of more than 6 for index insurance.

Evidence for ‘irrationally high’ not ‘irrationally low’ uptake

Observed demand for index insurance

<table>
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<tr>
<th>Premium / Birr</th>
<th>Frequency</th>
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<tbody>
<tr>
<td>0</td>
<td>3%</td>
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<tr>
<td>3</td>
<td>13%</td>
</tr>
<tr>
<td>6</td>
<td>18%</td>
</tr>
<tr>
<td>9</td>
<td>21%</td>
</tr>
<tr>
<td>12</td>
<td>20%</td>
</tr>
<tr>
<td>15</td>
<td>25%</td>
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A template for formal insurers

1. Think of role as that of reinsurer.
2. Contract with economically and socially contiguous groups:
   - Cheap loss adjustment technology
     ⇒ cheap cross-reporting
   - Can sustain (at least partial) risk pooling
3. Use contracting power to support nonmarket insurance
4. Condition transfers on any cheaply observable indices / sample-based indices...
5. ... but also offer indemnity-based stop loss cover (gap insurance)
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Suggestions for future research

1. Economic theory
   - Optimal contracting
   - Welfare effects of subsidies

2. Field experiments

3. Laboratory experiments are well suited to normative questions
   - Do subjects make ‘good’ decisions about hedging products?
   - How effective is education / financial advice?

4. Operational issues for scaling up agricultural insurance
   - Design, pricing and risk financing for developing countries
     - cf. IAA and UK actuarial profession working parties
   - Analysis of basis risk in different contexts
   - Constructing objective financial advice
   - Improving area yield indexed insurance

5. Macroinsurance for the poor